NACELLE AND MOUNTING ARRANGEMENT FOR AN AIRCRAFT ENGINE

TECHNICAL FIELD

This invention relates to aircraft propulsion systems and more particularly to a nacelle and mounting arrangement for aircraft engines.

BACKGROUND ART

Propulsion systems for powering modern commercial aircraft may include a high bypass ratio ducted fan engine, housed within an aerodynamically streamlined nacelle, and joined to the aircraft by an aerodynamically streamlined pylon.

The ducted fan engines used in these propulsion systems have a core section whose internal components include one or more axial flow compressors with radially extending blades rotatably driven about a longitudinal axis by one or more corresponding axial flow turbines also having radially extending blades. A core case, circular when viewed along the longitudinal axis, surrounds the compressors and turbines to form the outer flow path boundary of the core section and serve as a structural frame or backbone for the engine. Circumferentially extending blade tip seals are positioned on the inner surface of the core case radially outward of the rotating compressor and turbine blades and in close proximity thereto to ensure high efficiency.

A fan section, larger in diameter than the core section and concentric therewith, includes fan blades mounted in a hub, rotatable about the longitudinal axis and surrounded by a fan case which is circular when viewed along the longitudinal axis. A plurality of radial fan struts secures the fan case to the core case. A circumferentially extending fan tip seal is positioned on the inner surface of the fan case radially outward of the rotating fan blades and in close proximity thereto to ensure high efficiency.

The engine, as installed on an aircraft, is housed within a streamlined nacelle including an inlet, an intermediate fairing and an aft fairing. The inlet extends forward of the fan case and is firmly secured to a forward flange thereof. The intermediate fairing is a pair of access doors for maintenance access or engine removal, each door being hinged to a pylon forward extension as described more completely hereinafter. When the access doors are closed around the fan case, they latch together at their juncture so that each door encompasses approximately 180° of the fan case circumference. The aft fairing has an inner core cowl closely surrounding and substantially coextensive with the core section and an axially shorter fan duct outer wall concentric with the core cowl. The core cowl and fan duct outer wall define an annular, axially extending fan duct for conducting a fan flow stream in the axial direction. A fan duct discharge plane at the trailing edge of the fan duct defines the aft terminus of the fan duct.

A pylon, which includes an internal structural framework enclosed within an aerodynamically streamlined skin is secured to the aircraft, for example, to the lower side of an aircraft wing, and extends across the fan flow stream to mount the engine external to the main structure of the aircraft. Three sets of mount links extend between the pylon and the core case to connect the engine to the pylon. A forward link set carries vertical and lateral forces such as the engine's own weight and wind gusts acting on the core cowl. An aft link set located aft of the forward set accommodates

vertical and lateral forces as well as torque reactions that accompany engine acceleration, deceleration or rotor seizure. An axial link set transmits axial forces, for example, engine thrust. All of the forces and torques acting on the nacelle or engine are carried through the mount links into the pylon structural framework to the aircraft. Accordingly, the pylon is a large, heavy component having substantial surface area exposed to the fan flow stream. A forward extension of the pylon extends axially forward beyond the interface between the intermediate fairing and the fan duct outer wall and includes the hinges for the intermediate fairing.

Among the forces imposed on the nacelle during aircraft operation is an aerodynamic force resulting from aircraft maneuvers hereinafter referred to as the nacelle aerodynamic force. The nacelle aerodynamic force is analogous to the lift force exerted on the aircraft wing and is especially sizeable during takeoff and other maneuvers involving high angles of attack or rates of change thereof. The nacelle aerodynamic force is distributed nonuniformly over the nacelle surface in both the axial and circumferential directions, but is predominant near the forward edge of the inlet at a circumferential location dependent upon aircraft orientation and wind gusts. The nacelle aerodynamic force is transmitted to the engine and is reacted at the mount links. At takeoff rotation, for example, the nacelle aerodynamic force may be directed vertically upward so that the forward mount links impose a downwardly directed reaction force on the core case while the aft mount links place an upwardly directed reaction force on the core case at a location aft of the forward links. Since the mount links restrain the engine, the associated reaction forces, acting in concert with the nacelle aerodynamic force, bend the core and fan cases relative to the longitudinal axis, an effect referred to as backbone bending. Some aircraft maneuvers may also superimpose inertial forces on the nacelle aerodynamic force with additive or offsetting effects.

The nacelle aerodynamic force also distorts the shape of the inlet, and hence the fan case, so that fan case circularity is disturbed, a condition commonly known as ovalization, although those skilled in the art understand that the distorted shape depends on the exact magnitude and distribution of the nacelle aerodynamic force.

Both ovalization and backbone bending can cause the cases to intrude on the essentially circular path followed by the fan, compressor and turbine blade tips. The resulting contact between the blade tips and the seals positioned on the inner surfaces of the cases erodes the seals with a concomitant and permanent loss of engine efficiency.

Ovalization and backbone bending can be accommodated with increased clearance between the rotating blade tips and the surrounding cases, however, this introduces an efficiency loss not unlike that associated with seal erosion.

In the current generation engines, ovalization and backbone bending are mitigated by the use of stronger, and hence heavier cases and fan struts than would be required if the nacelle aerodynamic force was not present. However, the use of heavier cases and struts to mitigate ovalization and backbone bending in future generation engines will impose a significant weight penalty. Future generation engines are likely to have a higher bypass ratio (the ratio of airflow passing through the fan section to that passing through the core section), and therefore, a higher ratio of fan section diameter to core section diameter, than present generation engines. Achieving higher bypass ratio by decreasing the core section diameter renders the core case inherently less capable of resisting backbone bending. Conversely, achiev-